VETERINARY EUGENICS*

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THERE may be some who require enlightenment upon what exactly are the conceptions embodied in these two words, veterinary eugenics. To explain all that could be included within such a title would be far beyond the scope of this paper. I may be permitted to point out that if we define eugenics in the widest sense, namely as " a study of the influences which improve the inborn qualities of a race, and especially the development of those qualities to the highest degree "—which is the *Encyclopædia Britannica* definition, and if we restrict the word " veterinary " to its modern meaning† —namely, " pertaining to animal health and disease," we are faced with a structure possessing such a multitude of differing facets, comprising the whole of livestock improvement, that we must choose only some one or two to examine in detail.

The Historical Background

The control by man of animal breeding, which has without doubt achieved its maximum results in Great Britain, has not been effected by conscious scientific progress. For some 150 years or more, breeders of livestock in this country have had no definite settled policy, no clearly envisaged goal at which they could aim, apart, of course, from the production of the animal which would sell for most money. If I may expand this idea in some detail for one specific breed it will serve to illustrate the circumstances which have, more or less, applied to various other breeds and to a very large extent to the British livestock industry as a whole.

Perhaps the most famous breed of cattle produced in these islands is the Shorthorn—a breed which now can be readily divided into at least three distinct categories: the beef type; the dairy type; and the so-called commercial type which can be utilized for dual-purposes, i.e. for either beef or milk production. Before about 1790 the Shorthorn did not exist as a pure breed. A few men of great individualism, courage and foresight, whose names to-day are historic in agricultural circles—Bates, the Collings brothers, Booth, Amos Cruikshanks—at different times during the later eighteenth and the nineteenth centuries began selective controlled breeding. Some followed the principles laid down by Bakewell—the doyen of all livestock breeders; others followed their own ideas and ideals. The hitherto very heterogeneous, even mongrel breed, was in their hands moulded and shaped until slowly a certain degree of uniformity of type began to emerge. What had hitherto been a collection of animals liable at any moment to produce creatures possessing no characteristics or perhaps possessing almost every bovine characteristic, by dint of inbreeding, constant selection and elimination of undesirables from further breeding, began to take shape as a breed possessing some uniformity. The mob plasticity of the original stock slowly became less, and a more concrete fixed type grew in its place.

The pioneers were followed nearer to our own times by men no less able or successful —especially and most pre-eminently William Duthie of Collynie who died only a few years ago, to whom has been given the ungrudging title of the " Shorthorn King," the man who practically founded the modern Scottish beef Shorthorn, the supreme individuals of which still command prices running up to thousands of pounds per head. The work of these men and numerous others is being pursued and continued to-day by modern breeders, and short of calamity will continue in future indefinitely and incessantly.

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† The old meaning of " veterinarii " is those who looked after the beasts of burden. This might restrict the word to horses; although a cow giving 3,000 gallons of milk, i.e. 13½ tons, is also possibly a " beast of burden "!

It becomes pertinent to ask: What was the guiding star which led these men? What was it that enabled them to foresee what would be the proper type to breed? How could one analyze their policies, and use them ourselves? I think to these questions there is no answer. Each of the great animal breeders was a man who was *born*—an individual who sometimes owed little or nothing to his environment (Duthie was originally a branch bank manager)—a man who had in his mind a clear-cut conception of what to him was the perfect animal, and who, aided by a mastery of the art and the craft of animal breeding (two complementary necessities), sought to conjure from among his material this perfect type. Different men used differing methods: some practised the closest inbreeding; others tried to correct deficiencies in one sex by mating them with animals in which the required characters were markedly developed.

Perhaps you wonder where this historical survey is leading. I wish to give you some idea of the stocks upon which present work is carried out, and to enable you to contrast the patient, sure, steady progress of the older breeds with what happens to-day. In these days we are rich in everything except time. In the days when the foundations of British livestock pre-eminence were laid, time was a far more plentiful commodity than it is to-day. The older breeders could afford the time to make their matings in the unhurried, dignified and natural manner. The bull was not just a supply factory; he was the chief actor in the drama. His likes and dislikes were considered; he was nurtured and studied and observed and managed, with a view to keeping him up to concert pitch, in a way which would probably amaze many of you if you heard the details.

I chose the early history of the Shorthorn not because efforts with this breed were more intense or successful, but simply because it serves admirably as an index to what happened and is happening with every other British breed. There are names connected with the foundation of other cattle breeds quite as famous as those of the men who founded the Shorthorns, and this applies also to horses, sheep and pigs.

So much then for one aspect of livestock eugenics—perhaps hardly "veterinary eugenics"—except in so far as it may indicate that in Great Britain the stocks of animals which the veterinarian must now use have already, in a very large measure, been improved. But breeding alone has not been responsible for the high general level of excellence possessed by British livestock. There has been, almost *pari passu*, tremendous improvement in the animal's environment and management. Problems of nutrition, physiology, disease control, and all that is included in the comprehensive term "animal management," have engaged attention and a complete or partial solution has been found for at least most of them.

Economic Factors

To some extent the direct application of results obtained has lagged behind the knowledge of the facts. In every branch of knowledge there is always a time lag between discoveries and their application; but this lag is now of far shorter duration than formerly. It may be stated without hesitation that many of the most serious scourges of the animal population could readily be eradicated from Britain were there no economic factors involved. Bovine tuberculosis, for example, could be eradicated in Britain, if the farmer and the country could face the cost. Similarly, we possess the knowledge and the ability to effect complete control and ultimate elimination of many other animal diseases, such as sheep scab, distemper of dogs, rickets, contagious abortion, swine fever, Johne's disease of cattle, bovine mastitis, pullorum disease in fowls, and probably many others, just as some even more serious diseases, e.g. rabies, glanders, pleuro-pneumonia and sheep-pox have been eradicated.

Perhaps I have said enough to show that, in contrast to the position to-day in connection with human affairs, a great deal has already been done to effect such improvement among the domesticated animals as will enable them to achieve a reasonably

satisfactory equilibrium in relation to their environment. Man's animals are in fact better bred than is man himself. In other words, keeping in mind that we demand meat, milk, eggs, work, and offspring from our farm livestock, the types which have been evolved are those which under normal farm conditions, in the shortest time and with least labour, will give the best economic returns.

Some Problems of Livestock Improvement

I must not, here, give an impression that all British stock is perfect. This is by no means the case. There is still much room for improvement, and far too many animals with inferior qualities and potentialities are retained for breeding instead of being castrated or otherwise eliminated. The general level of efficiency is, however, high, and all British breeds are without exception immeasurably superior to the stocks from which they originated.

But few other countries, if any, are in this fortunate position. In some, such as the Argentine, Canada, Australia and New Zealand, it is still necessary for one or another reason to maintain a constant stream of new blood from Britain, so that such improvement in the local cattle stocks as has already been brought about will be maintained and increased. In others, such as Russia in particular, a previously fairly satisfactory population of domesticated animals was allowed, owing to political upheavals, to degenerate into a mixed heterogeneous mongrel stock, very much like the London pigeon, or like the animal population of Britain prior to improvement. An average or good-grade stock deteriorated into " scrub stock." In yet other countries, especially in some of our African colonies, in some countries in South America and other areas, improvement of local stocks is hindered or made difficult by the incidence of diseases transmitted by coitus, or by diseases to which local races have in the course of time acquired a tolerance or even immunity, but which make the importation of improved stock not possessing this tolerance, an impossibility. In many areas of Kenya, Tanganyika and Uganda, local cattle possess a resistance against trypanosomiasis (a disease due to blood parasites transmitted by an insect vector), whereas British or European cattle possessing superior conformation or performance carry no such immunity.

For these and many other reasons, therefore, it has become necessary to evolve techniques which will enable man to effect a greater degree of control of livestock improvement, and to speed up the processes of reproduction to a faster rate than was possible in former times.

One of the chief factors which has made this possible has been the application of artificial insemination to horse, cattle and sheep breeding in particular; another has been the development of early methods of pregnancy diagnosis—especially in the mare; and intensive studies of the physiology of reproduction including lactation, and of the pathology of sterility, have each contributed much valuable information, which will without doubt contribute even more help in future.

Indications for Artificial Insemination

To those who have an incomplete anatomical knowledge it is somewhat difficult to explain in detail the methods of producing artificial insemination in animals, and I propose to deal with them in the simplest manner. The following are among the reasons for employing artificial insemination:

(i) To make reproduction possible in cases of infertility due to discrepancies in size between male and female, abnormal physiological function, lack of uterine tone, etc., when there is no other pathological or physiological bar.

(ii) To conserve the energies of males of proved superior quality, or alternatively to enable a single superior male to become the sire in a single breeding season of a far greater number of offspring than would be possible from normal matings. This accelerates the rate of improvement of a species of livestock in which there is a comparative dearth of superior males but a superabundance of breedable females often of inferior quality (e.g. in Russia and the Argentine).

(iii) To avoid (*a*) infection of males with diseases contracted during, and transmissible by, coitus; or (*b*) spread of coitally transmitted disease among female breeding stock by the agency of the male.

(iv) To breed from animals which, being in captivity or under domestication, might otherwise be "shy breeders" or refuse to mate (e.g. silver foxes and martens).

(v) To overcome sex antagonisms, either between animals of differing breeds or species (hybrids), or in those peculiar cases of repulsion which apparently have a psychological basis.

(vi) To explore the scientific possibilities of interspecific hybrids which might have important economic uses—e.g. argali × domesticated sheep in Pamirs, and zebra × domesticated horse. There are other theoretical possibilities, such as the eland × cattle cross, the buffalo × cattle (the "cattallo"), and so on, in which hybrids have already been produced by natural mating.

Normal Reproduction in Domesticated Animals

Before dealing with the technique of artificial insemination, it is desirable to say something more about normal reproduction in the larger domesticated animals. As is well known, all farm livestock sires are polygamous, but this polygamy is not a constant feature. The normal average number of mares served by an adult thoroughbred stallion in a season (say February to June) is about forty; in the heavy draught breeds (Shire, Clydesdale, etc.) with a breeding season from March to July, it may be almost any number between 80 and 120. Most of these mares are given at least two separate services; many need three, four or five, or even more. There are, however, some really amazing records for individual heavy draught horses. The famous Clydesdale stallion, "Dunure Footprint," for instance, in one particular season served 480 mares. A groom slept in his loose-box, and day and night an alarm clock, set for every two hours, fixed the time for a fresh mare to be brought in for service. The record of fertility for this particular year's services is normal, about 64 per cent., and there was no diminution in the quality of the offspring, if one can judge by the prices obtained for many of them and by the number of prizes they obtained in the show and sale rings later. One breeder, for example, sent forty-five mares to this stallion, and forty-one of them proved to be in foal after one service only.

The adult bull may serve on an average between fifty and seventy cows in a year, the ram fifty to sixty (up to eighty or ninety in particular instances), and the boar some twenty-five to thirty-five sows.

It should be clearly realized that these are all figures for adult animals, and that most young or adolescent animals are only allowed to serve half or two-thirds of these numbers. It should also be realized that the average level of fertility of some of our farm livestock is rather low. In the horse, for example, apart from ponies living a free life, the average fertility is only between 56 per cent. and 68 per cent. of the mares served. It is certainly higher in cattle, sheep and pigs, though few sires leave 100 per cent. of the females they serve pregnant. Without doubt much of this low fertility is directly due to the trammelling effects of domestication systems on the free play of reproductive impulses. Females are not always served at such a time that the recently erupted ovum has a chance of being fertilized by a living active spermatozoon. Frequently service is too early; sometimes it may be too late.

It is very difficult to obtain adequate and reliable figures about differential fertility, as between the beginning, the middle, and the end of the serving period, for there is a great deal of individual variation. I think, however, it is safe to say that where the breeding season is restricted to certain months of the year only, as in the horse and sheep, there is a certain proportion of unsuccessful matings at the very beginning of the season; then fertility rises and remains at its maximum for the greater part of the period, but tends to fall off again with the later services at the end of the season, especially in a sire which is expected to fertilize more females than whatever the number may be of which he is physiologically capable. This latter drop in fertility may, however, not always be

attributable to the sire, since if there should be any females among those he serves which, for one reason or another, are sterile, a big proportion of these will almost certainly fall among those served latest in the season, and may contribute towards an apparent terminal infertility. Physiologically, however, it is to be expected that during a period of exceedingly active spermatogenesis, there will come a time when a greater or lesser degree of exhaustion of spermatogenic tissue occurs. This brings up the important question of the great desirability of adequately spaced matings. Unfortunately, the periodicity in horses and sheep is always—or nearly always —determined by the frequency, duration and sequence of œstral manifestations in the mares and ewes. On one day, no females may be at the right stage of œstrus for mating; on another, there may be four, six, eight or even more, and few owners and no rams are content to postpone service until a later date (matings in horses being usually controlled, but in sheep the animals are at liberty).

Problems in Britain and Abroad Compared

From this brief outline, it may perhaps be appreciated that successful artificial insemination can bring to the aid of the stockowner a very powerful expedient for correcting some abnormalities of reproduction. In Britain, however, the need for the development and extension of the use of artificial insemination amongst the various species of domesticated animals is not by any means so acute as it is in many countries abroad. Britain is essentially a "sire-producing" country; many overseas states are "sire-importing" countries—for example, Argentine, Australia, New Zealand, South Africa and Russia. Wherever there is an absolute or comparative dearth of pre-eminent sires, there artificial insemination can be of the greatest aid to rapid livestock improvement. As will be mentioned later, it is possible, by using a technique in which each ejaculation is diluted with a suitable fluid (now called a "dilutor"), and then divided into a series of fractions, to effect successful insemination of eight, ten or twelve or even up to fifteen or sixteen females in place of the one only which would be impregnated by a normal service. The accelerating effect of this technique in mass improvement schemes can be readily realized. From a single bull during one season over 1,000 calves are stated to have been produced by the Russian investigators. Instead of perhaps fifty to ninety lambs from a ram, in a single season over 1,200 have been produced, and it is claimed to be possible to inseminate 4,000 ewes during a forty to fifty-day season by the latest methods in which as many as fifty ewes may be impregnated from a single ejaculation. As already mentioned, however, the British stockowner is not so much interested in mass improvement, as in securing the maximum numbers of offspring from a particularly prepotent or pre-eminent sire.

Obstacles to Extended Use of Artificial Insemination

At this stage it may be well to mention three other facts which serve to illustrate why very large numbers of females are not being inseminated in Britain as they are in Russia. Livestock-breeding is a competitive business, and he who breeds a particularly superlative bull or stallion naturally wishes to reap some financial rewards for himself. These rewards are represented partly by prize money, but much more so by the value of the offspring. For example, the owner of a "triple crown winner," or the owner of a supreme Royal and Highland Champion Bull, will most naturally wish to reserve as many as possible of his own brood mares or breeding cows for service. To maintain something in the nature of a partial monopoly of offspring from such a sire is financially profitable. To multiply the numbers of such offspring tenfold is to do far more than to decimate the price per head obtained. Secondly, when natural mating occurs there is a considerable degree of security of pedigree for the offspring. Were artificial insemination to become a common technique in this country, a certain proportion of the more unscrupulous breeders might succumb to the temptation of substituting sperm from an inferior sire for one of superior merits—with the risk of disastrous results to pure

breeding. Of course, it would be relatively easy to devise a mechanism whereby this latter disadvantage might be overcome, but the former would still operate. There is also a third reason. The use of a large number of sires in any given breed keeps that breed, when viewed as a whole, in a satisfactory state of genetic fluidity. When the genetic characters of any one animal, superlative though it may be, become unduly concentrated within a breed through excessive use, much of this malleable breed fluidity is lost, and more fixity of characters results. If there should be a sudden change in breed fashions or in the nature of the public taste, or if some adverse character begins to assume undue general prominence, there is a more restricted choice of out-crossing available to the breeders, and valuable time may be lost in achieving once more that desirable lack of undue rigidity which permits rapid breed-modifications to be made to meet sudden demands.

Methods of Sperm Collection

There is a choice of several methods of collecting sperm for animal insemination. These methods, some of which have distinct advantages, will be briefly outlined here.

(*a*) *Collection from a normal service.* This method has been in common use for some considerable time. The female in œstrus is served in the normal way, and immediately afterwards semen is collected from the anterior vaginal floor, by a long syringe-like instrument (the inseminator), which is then inserted through the cervix into the uterine cavity where its contents are expelled. This method has certain disadvantages: there is the possibility of infection being transferred from male to female or vice versa; it is essential that the female shall exhibit œstrus; and it is generally possible to inseminate only one or perhaps two females from one service, so that male energies are not greatly conserved. Alternately, there is greater guarantee of pedigree, less chance of unscrupulous malpractice, simplicity of technique, and less risk with a valuable highly strung sire or dam of any untowards psychological sequelæ.

(*b*) *Collection by means of the artificial vagina.* There are two main types of these: the Russian type which is virtually a pure latex rubber lining for the vagina of the female; and the Cambridge pattern, which consists of a felt-covered metal or bakelite rigid tube, into which fits a latex rubber liner. The cavity between tube and liner is filled with warm soapy water and air, and at one end is a glass collecting-chamber. Lubrication is effected by means of pure white vaseline or liquid paraffin. The penis of the male is diverted just before penetration into the artificial vagina held alongside the female, and the semen is collected in the glass container. In the Russian type, the sire serves into the rubber vaginal lining fitted to the female; this receives the ejaculation and is subsequently removed. From either type the subsequent procedure is similar. The semen is obtained pure and uncontaminated by vaginal secretions or saprophytic or pathogenic vaginal organisms, and it can be diluted suitably and used for the insemination of such other females as are in œstrus, or it may be used undiluted after division into appropriate fractions.

The disadvantages are that a female in œstrus is necessary, or alternately a specially trained female which will allow the male to mount even though she is not in season. The technique is not so simple, and for the larger animals two operators are usually required, while the apparatus must be maintained scrupulously clean and bacteriologically sterile. Advantages are that coital infections are avoided and that the complete uncontaminated emission is available and under complete control.

(*c*) *Collection by service-crate.* The purpose of this is to secure the female in such a way that irrespective of whether she is in œstrus or not she cannot escape from the attentions of the male, which will mount and serve either into a Russian or Cambridge-pattern vagina as above. Up to the present, the method has been chiefly employed for sheep and cattle, since the females of these species are more tolerant and placid. Mares will probably never lend their co-operation to

man for purposes of collection by service-crate; thoroughbreds certainly will not.

(*d*) *Collection by phantom female.* Certain sires, especially rabbits, bulls and rams, if a stuffed imitation of a female is presented to them, in which the skin is used and the general outline is preserved, will mount it and serve into an artificial vagina held in suitable position. Such phantom females are useful in that no female in season is required and no actual contact between the two parents takes place. Subsequent procedures are the same as those already mentioned above.

(*e*) *Collection by electrical stimulus.* A technique has been elaborated within the last few years whereby, by passing an electrical stimulus through the lumbar region of the spinal cord, a normal emission of semen can be obtained in rams. This itself is remarkable, but when it is mentioned that previous administration of certain drugs to the ram will increase the survivability of the sperms from about two to four days up to as much as sixty-four days in one instance, and from twenty-four to forty-eight days in numerous instances, it may be realized what tremendous possibilities there are in the further development of this technique in future years. So far as I am aware, this method of collection has not yet been attempted successfully in the larger domesticated animals, but there seems no reason why it should not be applied to bulls at least. It has great possibilities in connection with the examination and investigation of breeding sires which are not functionally up to normal breeding standards as regards such matters as sperm count, density, total volume, and reaction, or are possibly infected by such organisms as *Brucella abortus*, or by tuberculosis of the genital organs.

(*f*) *Collection by frictional methods.* This hardly merits more than mere mention, but since it is sometimes practised by certain dog-breeders and owners of silver fox farms, especially abroad, perhaps it should be included. Manual or other friction is carried out until an emission is obtained; this is collected in a test-tube and used to inseminate such females as are in œstrus. The method, though apparently eminently practical, and of use to prevent injuries to valuable breeding animals through fighting or even playfulness, is a somewhat rough and ready one and does not commend itself to modern ideas.

It will be seen that the steps in the development have been (i) a normal female in full œstrus which is given a normal service; (ii) a normal female in œstrus given an abnormal service; (iii) a normal female not in œstrus given an abnormal service; (iv) an abnormal female (phantom) with an abnormal service; and (v) no female at all—electrical and manual stimulus to the male. Do not think we can dispense with the male just yet!

Technique of Insemination

The actual technique of insemination of the collected sperm does not present any undue difficulty. The appropriate amount is introduced into or through the cervix by means of an all glass or other non-metallic syringe, using a suitable means of illumination and a vaginal speculum. No evidence is available to show that any active co-operation on the part of the female is required, apart from the obvious one of exhibiting normal signs of full œstrus. No orgasm or other psychological or physiological disturbance occurs during insemination, yet fertility in carefully inseminated groups of females is recorded as being frequently much higher than when normal service occurs.

Possible Lines of Development

It may be mentioned that with further development of methods of employing the various gonadotropic hormones now being actively investigated in many centres, it may probably be possible to induce artificial œstrus in groups of females at any given prearranged date; but to be effective such œstrus will have to be accompanied by the development of mature and ripe follicles and by their ovulation. As a corresponding development, the preservation of spermatozoa in an active state for considerable periods will be required. When this is possible, Man will have achieved almost

complete control of the mechanical features of reproduction, and it will then be possible to superimpose any desirable modifications upon the sexual rhythms which at present are to a large extent dependent upon or at least associated with seasonal and climatic conditions. If, for instance, it became economically desirable for a portion of lamb-crop to be produced in autumn or mid-summer instead of early spring, this could readily be arranged. Appropriate use of hormone preparations is readily capable of overriding many or most of those sub-normal or abnormal physiological or psychological functionings (such as unduly long or short œstral periods, irregularities in rhythm, lack of adequate desire, or undue desire) which at present appear to be concomitant with the intensification of modern methods of livestock production no less than they are of the progress of human civilization.

Before these days arrive, however, there is much to be done. As yet, although much more is known about reproductive physiology than formerly, there still remains a great deal to be investigated. Especially is this the case regarding hormone therapy, the exact vitamin requirements needed during reproduction, the details regarding anti-hormone production, the control of infections of both male and female generative tracts, and the exact influences of feeding, exercise, and general methods of management upon breeding, both in man and animals.

Conclusion

Breeding is an exact science which, like any other science, possesses its own rigid laws. Just how far knowledge obtained from a study of reproduction in animals can be used to solve the problems of mankind remains to be seen. Doubtless there are households where the disappointment occasioned by a lack of offspring might have been avoided by judicious employment of these modern reproductive techniques; equally certainly similar opportunities for their application will arise in future. It would seem that careful consideration might be given to the *pros* and *cons* of the problem as it applies to man. There may be difficulties to be faced: staunch supporters of the established social structure of the modern world might look askance at such suggestions; the law of entail and inheritance might have to be modified; and without doubt there would be bitter antagonism from those whose knowledge of anatomy and physiology is limited to what they have learnt by the exercise of their own limited powers of observation.

On the other side of the picture, however, there are very definite advantages to be obtained. In addition to contributing to the sum of human happiness by making progeny possible where otherwise there could be none, artificial insemination might open up wider and truly eugenic vistas; some control over the temperament, mental or physical abilities of future races might be exercised and our sons and our sons' sons be consequently better fitted to cope with the exigencies of a civilization that becomes more complex and a society that becomes more exacting as the years pass.

In conclusion, I claim no originality for what I have put before you. Most of the work to which references have been made is contained in the post-war literature of this and other countries, particularly Russia; and so far as Man is concerned others before me have envisaged the Brave New World of to-morrow.